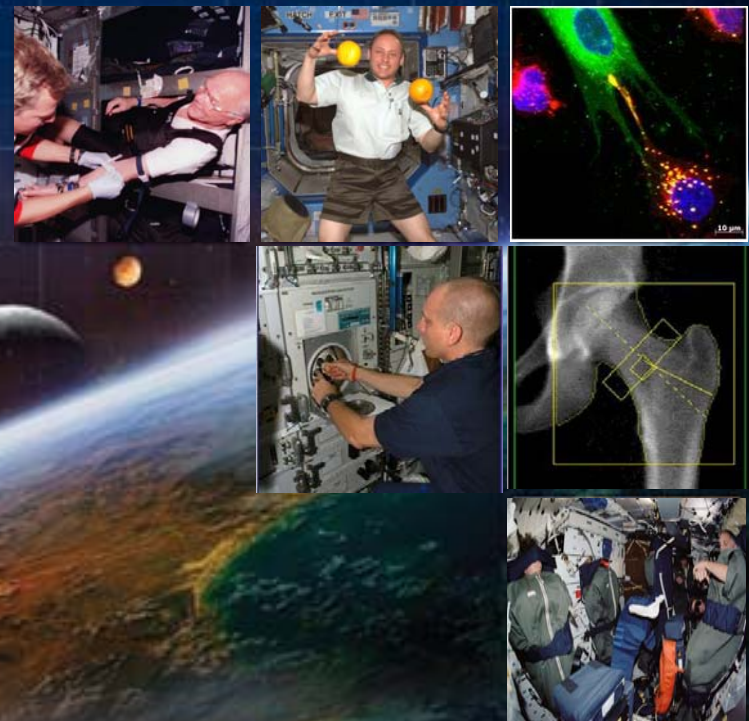


National Aeronautics and Space Administration



The Human Research Program at NASA

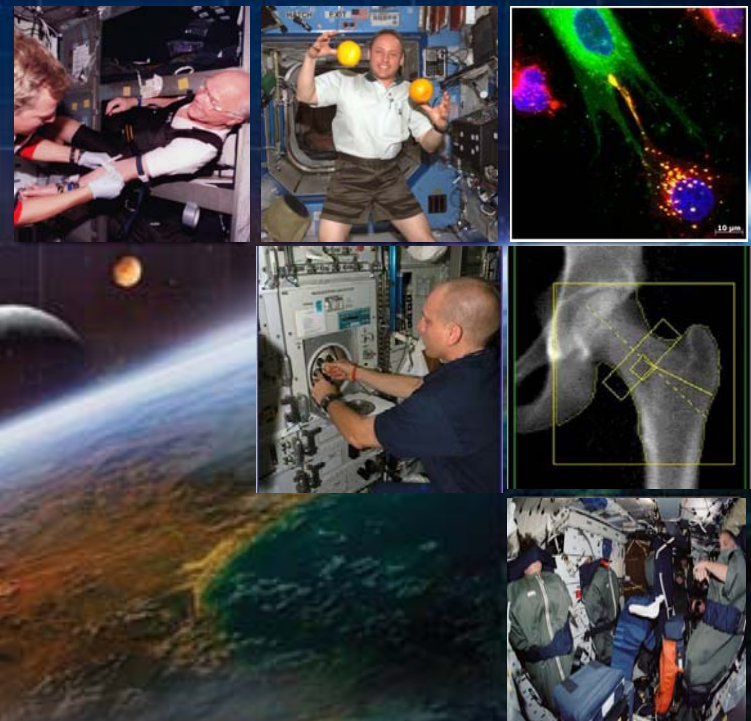


October 2013



What is HRP?

- ❖ Overview
- ❖ Management Approach
- ❖ Program Content
- ❖ Elements of HRP
- ❖ HRP Flight and Ground Facilities
- ❖ Interfaces and Collaborations



Overview: Human Research Program Mission



To enable space exploration beyond low Earth orbit by reducing the risks to human health & performance through a focused program of:

- ❖ Basic, applied, and operational research,

leading to the development and delivery of:

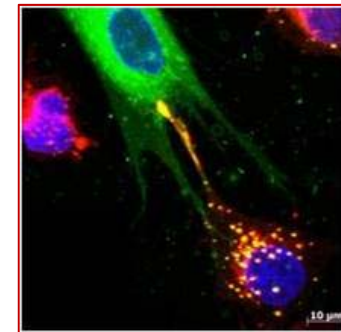
- ❖ Human health, performance, and habitability standards,
- ❖ Countermeasures and risk mitigation solutions, and
- ❖ Advanced habitability and medical support technologies



Overview: Human Research Program



- **Established in 2005 to focus NASA's research on the highest risks to human health and performance during exploration missions.**
 - ❖ Perform research necessary to understand and reduce spaceflight human health and performance risks in support of exploration
 - ❖ Develop technologies to reduce medical risks
 - ❖ Develop NASA spaceflight human system standards
- **National Research Program directly aligned with human exploration goals**
 - ❖ NASA Mission: *"Driving advances in science, technology exploration to enhance knowledge, education, economic vitality, and stewardship of Earth in the area of Human Health and Performance."*
 - ❖ Example: Strategic Goal 1: *Extending and sustaining activities across the solar system*
- **Highest health risks associated with exploration missions have been identified, documented, reviewed, and are actively managed**
- **Research underpinnings have been established by the National Academies**
- **Independent, external scientific review used extensively**
- **Collaborative research with Internationals and other U.S. Agencies**
- **Products include:**
 - ❖ Information to design exploration architectures, vehicles, and missions
 - ❖ Countermeasures
 - ❖ Research deliverables that define space medical, environmental and human factors standards (Standards define acceptable human health risk)
 - ❖ Technologies and Tools



Cell fusion after exposure to Simulated Space Radiation



Clay Anderson centrifuges Nutrition blood samples during Increment 15



Example of a study on the effects of center of gravity on performance

Management Approach: HRP Research Strategy



HRP employs a novel risk-based research strategy:

- Risks to space explorers are clearly defined (in collaboration with the Crew Health & Safety Program (CHS) and the Office of the Chief Health and Medical Officer (OCHMO)/Health and Medical Technical Authority (HMTA))
- Risk mitigation status is assessed for specific DRMs using extant evidence (vetted through Human Systems Risk Board (HSRB))
- Research tasks are prioritized to mitigate those risks most likely to present human system limitations to probable DRMs

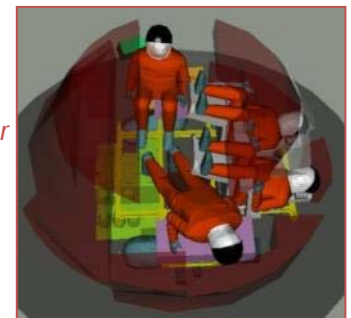


Example of a study on the effects of center of gravity on performance

HRP risks, contents, and priorities are vetted through independent review panels (National Research Council (NRC), Institutes of Medicine (IOM), National Council on Radiation Protection and Measurements (NCRP))

HRP leverages assets through collaborations:

- Operational medicine and technology development programs (e.g., CHS, Advanced Exploration Systems (AES)),
- Other space biomedical research programs (i.e., Space Biology, International Space Station (ISS) National Laboratory),
- Other US research agencies (e.g., National Institute of Health (NIH), National Science Foundation (NSF), Center for Disease Control and Prevention (CDCP))
- International Partners (IPs)



Seat layout for contingency EVA

HRP uses competitive solicitation processes and peer review to ensure high quality research



Clay Anderson centrifuges Nutrition blood samples during Increment 15

Program Content: Genesis of Human System Risks

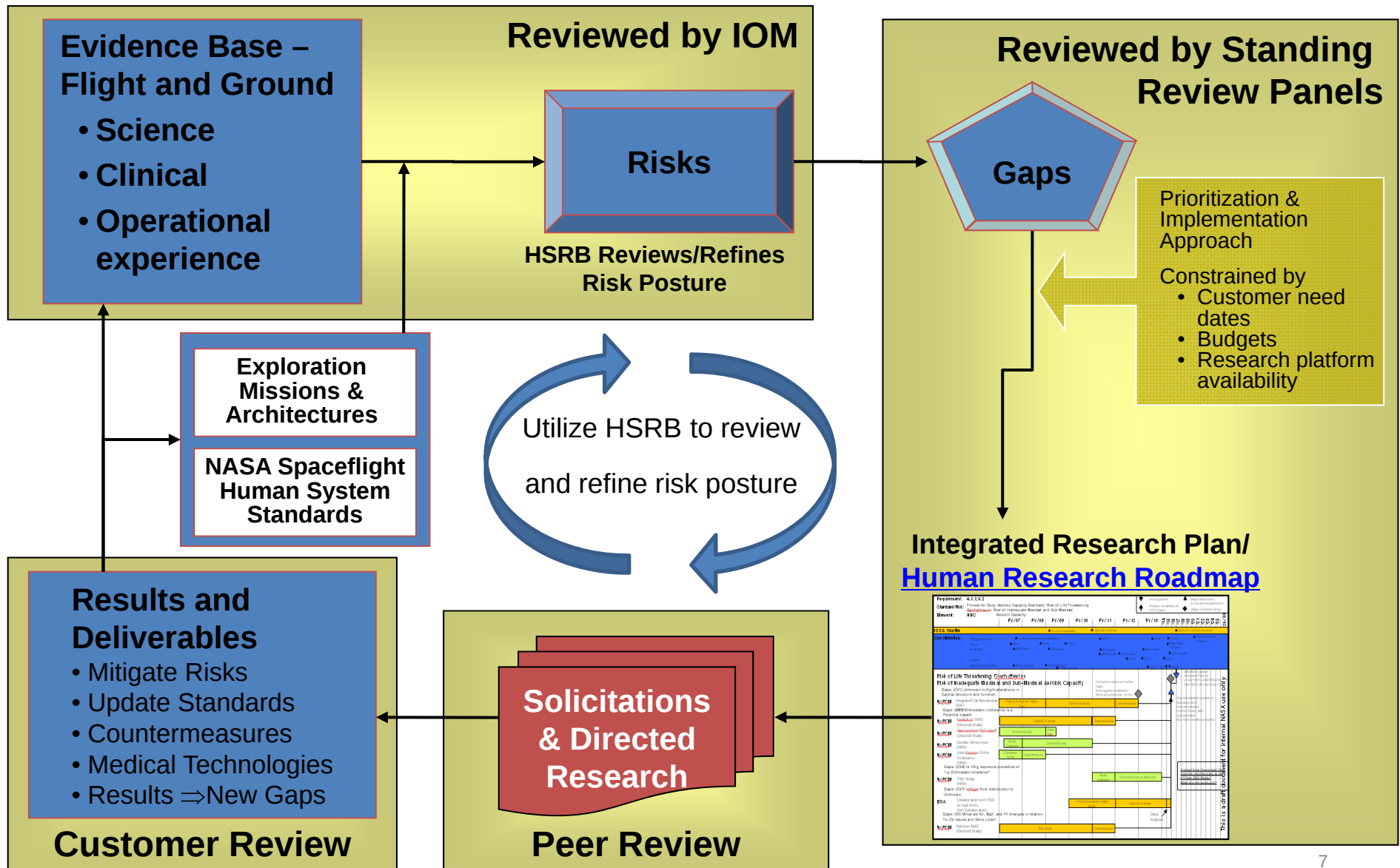


Primary Hazards Leading to HRP Risks

- **decreased gravity**
(including gravity transitions & launch & landing loads)
bone, muscle, cardiovascular, sensorimotor, nutrition, behavior/performance, immunology, human factors, clinical medicine
- **isolation/confinement & altered light-dark cycles**
behavior/performance
- **hostile/closed environment**
(including habitability: atmosphere, microbes, dust, volume/configuration, displays/controls,...)
behavior/performance, nutrition, immunology, toxicology, microbiology
- **increased radiation**
immunology, carcinogenesis, behavior/performance, tissue degeneration, pharmaceutical stability...
- **distance from Earth**
behavior/performance, autonomy, food systems, clinical medicine

Note that effect severity generally increases with mission duration.

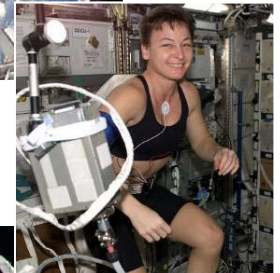
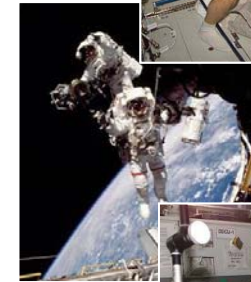
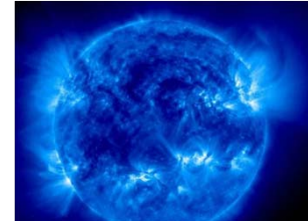
Risk-based Program Architecture: Evidence → Risks → Gaps → Tasks → Deliverables



Elements of HRP



- **Space Radiation (SR)**
 - ❖ Human health effects, limiting factors for vehicle environments and crew selection; computational shielding modeling; measurement and warning technologies
- **Exploration Medical Capability (ExMC)**
 - ❖ Medical care and crew health maintenance technologies (monitoring, diagnostic, treatment tools and techniques); medical data management; probabilistic risk assessment
- **Human Health Countermeasures (HHC)**
 - ❖ Integrated physiological, pharmacological and nutritional countermeasures suite; Extra-Vehicular Activity (EVA) related physiology research to support new EVA suit development
- **Behavioral Health & Performance (BHP)**
 - ❖ Behavioral health and performance monitoring tools and countermeasures (sleep/circadian; neurobehavioral; psychosocial), crew composition, selection, assessment, and training capabilities; intervention and communication techniques to support exploration missions
- **Space Human Factors & Habitability (SHFH)**
 - ❖ Anthropometry, display/control, usability, cognition, habitability, lighting, ergonomics; advanced food development; lunar dust characterization and toxicological testing, and characterization of microbiological hazards
- **ISS Medical Projects (ISSMP)**
 - ❖ ISS research integration and operations; includes integration of ground-based analog testing
- **National Space Biomedical Research Institute (NSBRI)**
 - ❖ Nationally competed/peer-reviewed research projects addressing above content utilizing investigators at more than 63 institutions in 23 states



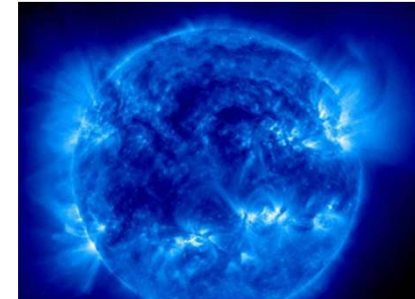
Elements: Space Radiation



Participating Centers: JSC, ARC, LaRC

- **Objectives:**

- Ensure that NASA can safely live and work in the space radiation environment, anywhere, any time
- Identify, plan and conduct radiobiological and physics research that yields the knowledge, data, tools, methodologies, recommendations, and technologies needed to guide and support the development of radiation risk assessment and protection strategies
- Develop scientific basis to accurately project and mitigate health risks from the space radiation environment



- **Exploration Products:**

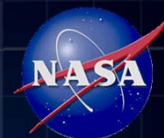
- Recommendations to Permissible Exposure Limits for exploration missions
- Radiobiological data, projection models, and computational tools to assess and project crew risk of cancer, central nervous system and degenerative tissue risks, and acute radiation syndrome from space radiation
- Computational tools and models to assess vehicle design for radiation protection
- Personal radiation monitoring technologies, transitioning to AES
- Uncertainty reductions to enable radiation protection design and crew constraints for exploration missions
- Assessment of effectiveness and development of physical or biological countermeasures

Elements: Exploration Medical Capability



- **Participating Centers: JSC, ARC, GRC, LaRC**
- **Objectives:**
 - Sponsor research and technology leading to the development of clinical care capability, medical equipment technology and medical informatics
 - Identify and test next generation medical care and crew health maintenance technologies (monitoring technologies, diagnostic capabilities, treatment tools and techniques)
- **Products for Exploration:**
 - Data and knowledge to support development of Health and Medical standards
 - Tools to support exploration operations, such as the Integrated Medical Model
 - Medical technologies that require fewer resources, cost less and are more reliable
 - Integrated medical system for exploration missions





Elements: Human Health Countermeasures

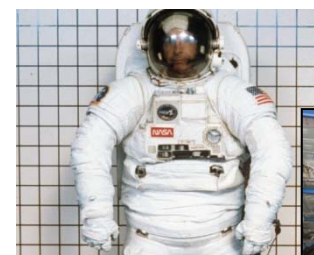
Participating Centers: JSC, ARC, GRC

Objective:

- Develop a validated integrated suite of countermeasures for exploration missions that ensure the maintenance of crew health during all phases of the mission targeting human physiologic and required performance capabilities at risk from space flight missions.
- Provide enabling facilities including Flight Analogs, and Human Test Subject Facility

Exploration Products:

- Inform development of Crew Health and Medical Standards
- EVA human-suit interface requirements and DCS prevention
- Integrated physiological countermeasures
- Validated exercise system requirements
- Visual Impairment definition & mitigation



Four Portfolios:

- **Cardiovascular & Vision**
- **Exercise and Performance**
- **Multisystem**
- **Technology & Infrastructure**
 - ❖ Digital Astronaut Project
 - ❖ Flight Analogs Project



Supporting Functions:

- **Human Test Subject Facility**

Primary Responsibility for 15 Risks with 85 identified gaps in the research plan

Elements: Behavioral Health & Performance



- **Participating Centers: JSC**

- **Objectives:**

- Identifies and characterizes the risks associated with training, living, and working in space and return to Earth
- Perform ground and flight research to inform Crew Health and Performance Standards and to prevent or reduce risk through countermeasures, tools, and technologies



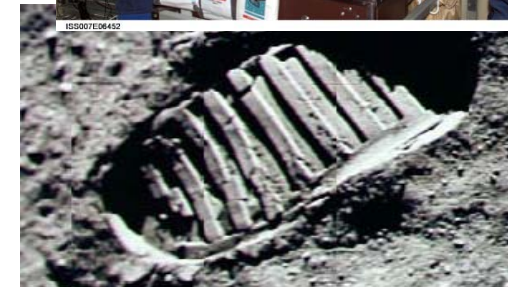
- **Exploration Products:**

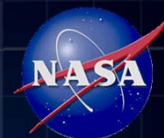
- Predictive modeling tools
- Workload and scheduling tools
- Risk assessment and monitoring technologies and tools
- Training tools for team cohesion and performance
- Inform development of Human Health And Performance Standards
- Crew composition and selection guidelines
- Behavioral health countermeasures

Elements: Space Human Factors & Habitability



- **Participating Centers: JSC, ARC**
- **Objectives**
 - Mitigate exploration mission risks associated with human-systems interface designs and operational processes.
 - Enable safe, nutritious, and acceptable foods to promote crew health and performance in exploration mission scenarios.
 - Mitigate risks associated with human exposure to environmental factors in exploration missions.
- **Exploration Products**
 - Development and validation of human-systems integration standards and guidelines (Human Integration Design Handbook)
 - Technology development in human factors areas, i.e.; training, procedures, human interface systems designs, analytical tools
 - Habitability – net habitable volume requirements
 - A food system that addresses nutritional, psychological, safety and acceptability and minimizes mass, volume, waste, power, and trace gas emissions
 - Lunar dust research and Space Flight Human System Standard development
 - Activities to review adequacy of microbiology standard





Elements: ISS Medical Projects

Participating Centers: JSC, ARC and KSC

- **Objectives:**

- ❖ Maximize the opportunity provided by both ground-based analogs and the ISS for human health and performance evaluations during long duration missions
- ❖ Use the ISS to understand the significant effects of long duration spaceflight on the human body in order to inform Crew Health and Performance Standards and protocols and manage exploration risks
- ❖ Manifest, integrate, operate and sustain human research hardware
- ❖ Support International Partners in ISS research, per agency agreements



- **Exploration Products:**

- ❖ Tools to enable HRP research, testing, and flight validation of technologies, countermeasures, and medical standards on board the ISS in preparing for exploration missions
- ❖ Infrastructure support to obtain evidence base in support of exploration human system risk management
- ❖ Analyze data from operational studies to improve research prioritization, aid operational decision making and reduce crew health risks
- ❖ Provide interface for international collaboration to maximize flight resources
- ❖ Continue integration with medical operations and leverage resources to improve access to flight

National Space Biomedical Research Institute (NSBRI)



- NSBRI leads a national effort for accomplishing the integrated biomedical research necessary to support the long-term human presence, development and exploration of space, and to enhance life on Earth by applying the resultant advances in knowledge and technology.
- NASA-supported corporation
 - ❖ Cooperative agreement with NASA
 - ❖ Governed by a consortium of 12 institutions
 - ❖ Organized into 7 teams that address major physiological or medical issues
- Reports at HRP quarterly reviews and maintains an NSBRI MSProject schedule as part of the HRP IMS
- Works with Elements and Science Management Office to select NRAs to help close the HRP risks and fill in the knowledge gaps



HRP Flight and Ground Facilities

International Space Station

- Critical to understanding and mitigating a majority of the exploration human risks
- Important test bed for space biomedical technology

NASA Space Radiation Laboratory (NSRL)

- Brookhaven National Laboratory (DOE)
- Critical to Space Radiation Research

Ground-Based Analogs

- Bed Rest Facilities
 - UTMB FARU (NIH)
 - :envihab (DLR)
- Isolation Facilities
 - Antarctica (NSF, International)
 - Isolation Chambers: Mars 500 (IBMP), **HERA**, Hi-Seas (HI)
- Environmental Chambers
 - AFRL, JSC, Duke





Interfaces and Collaborations

Extra-Agency

DOD

- Prepackaged Food
- Field Trauma Care
- Virtual Soldier

ISS Partners

- Collaborative research
- ISS utilization
- ISLSWG

NIH

- Clinical Research Centers
- Anti-oxidant research

DOE

- Low Dose Radiation Research
- NASA Space Radiation Lab

National Academies

- Research Recommendations

NSBRI

NAC

- Program Oversight

HRP

Intra-Agency

Fundamental Space Biology

- Microbial Risk
- Non-human models of physiological risk

MPCV

- Occupant Protection
- Exercise Equipment

ISS

- Utilization planning
- Medical Operations
- Exercise

OCHMO/ Med. Ops

- Standards
- Risk
- Countermeasures

OCT

- Cross-Agency Integration

AESD

- Radiation Shielding
- Human-Robotic Interface
- Environmental Monitoring
- Advanced Life Support